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Editors

Air Pollution in Eastern Asia: An Integrated Perspective

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Preface

Air pollution has a considerable impact on society in different regions of the world. According to the World Health Organization (WHO), more than three million individuals die prematurely each year from diseases produced or exacerbated by outdoor air pollution: heart failures (40 %), strokes (40 %), pulmonary diseases (11 %), and lung cancers (6 %). These diseases are not limited to the elderlies. Other adverse effects include crop and forest damage, reduction in visibility, enhanced acidic precipitation, eutrophication of water resources, and damages to buildings including historical monuments. By interacting with solar and terrestrial radiation and affecting cloud microphysics, air pollutants and specifically aerosol particles also contribute directly or indirectly to climate change. In recent years, the importance of feedbacks between climate and atmospheric chemistry has been the subject of considerable attention by the scientific community.

The development of economic systems based on industrial and commercial activities as well as services has been at the source of rapid urban growth in the past decades. At the beginning of the nineteenth century, only 3 % of the population lived in urban areas, and in 1950, only 80 cities had a population exceeding one million. Since the end of the twentieth century, half of the world's population lives in urban areas and almost 500 cities host more than one million inhabitants. As of 2015, 35 cities were considered to be megacities (https://en.wikipedia.org/wiki/Megacity), which are large urban areas with a population exceeding ten million. In China, the largest cities are Shanghai, Guangzhou, Beijing, Shenzhen, Wuhan, and Chengdu. The fast development of the economy in Asia has not been without detrimental environmental consequences: the level of air pollution has increased dramatically in the last decades, specifically in the corridor extending from Beijing to Shanghai. Eastern China is indeed constituted of a multitude of closely located cities, which represent substantial sources of primary and secondary air pollutants. At the same time, the dense population in these urban areas is severely affected by high levels of fine particles and oxidants. Air pollution must be regarded as a vast regional problem rather than the addition of several localized urban-scale disturbances.

Until a few years ago, surface measurements of atmospheric pollutants in China were sparse and, in fact, not easily available. The adoption of ambient air quality standards and the development of a national air reporting system have considerably improved the situation. Today, a large number of measurements are available and are very useful not only to monitor the daily variations or long-term trends in air quality, but also to analyze the effectiveness of the measures taken to reduce the sources of pollutants. Further, such data have become the basis for the initialization and the evaluation of air quality forecast models that have been developed and are now used operationally. Figure 1, which reproduces the result of an analysis performed by Rohde and Muller (2015) in eastern China and is based on measurements made at more than 1,500 monitoring stations, provides a quantitative estimate of the magnitude of air pollution. If one considers the fine particles with a radius smaller than 2.5 μm ($PM_{2.5}$) that easily penetrate deep in the respiratory system, 38 % of the population living in this part of China is subject to unhealthy

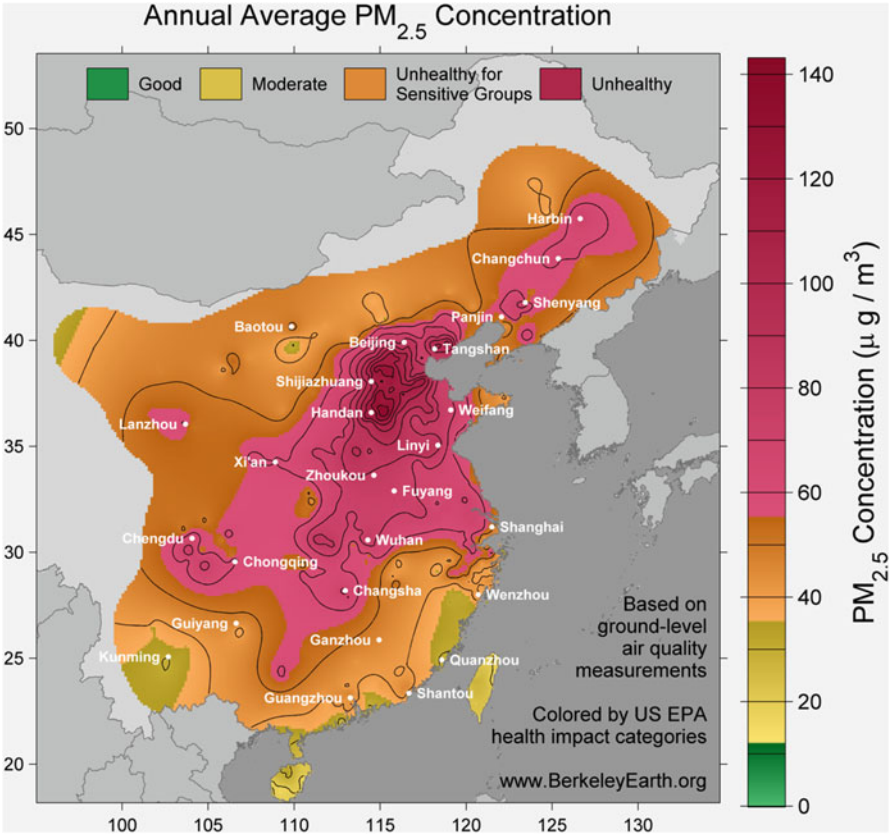

Fig. 1 Annual average pollutant concentration of $PM_{2.5}$ in eastern China in 2014 as determined by Berkeley Earth on the basis of surface measurements made at monitoring stations in China (Reproduced from http://berkeleyearth.org/)

conditions with average $PM_{2.5}$ concentrations exceeding 55 μg m^{-3} (red area on the figure). An additional 45 % of the population lives in areas labeled "unhealthy for sensitive groups" (orange area on the figure) with average $PM_{2.5}$ concentrations higher than 35 μg m^{-3}. The situation is less acute for PM_{10} particles (particles whose radius is less than 10 μm) and even less severe in the case of ozone, even though intermittent episodes of high ozone concentrations are observed during summertime. Concentrations of $PM_{2.5}$ higher than 500 μg m^{-3}, reaching in some rare occasions values of 600–1,000 μg m^{-3}, have been reported in urban areas during stable meteorological conditions in winter (Zheng et al. 2015). A challenge for the scientific community is to investigate the fundamental chemical, physical, and meteorological processes that produce and sustain elevated concentrations of secondary pollutants in eastern Asia. This question has motivated an interdisciplinary group of atmospheric scientists specialized in atmospheric chemistry and microphysics to contribute to two workshops supported by the International Space Science Institute (ISSI), one held in Beijing, China, and the second one in Bern, Switzerland. The presentations made during several intense days of discussions have been assembled in this volume.

The book is presenting an extended view on questions related to air pollution in Asia and specifically in China. It has been written by a group of experts from different continents for a broad audience involving scientists, educators and their students, environmental managers, policy-makers, as well as leaders in public administration and private corporations. It is organized around six distinct parts. The first five chapters in the first part of the volume offer a general perspective on issues related to air pollution including persistent haze events in eastern and southern Asia. The second part presents an overview of air pollution sources (i.e., anthropogenic and biomass burning sources). The third part analyzes in situ observations of chemical species in China, while the fourth part focuses on space observations of gas-phase and aerosol species. The modeling aspects are treated in the fifth part of the volume, which includes a presentation of several air quality forecast systems and an assessment of the role of urbanization on air pollution levels. Finally, the effects of air pollution on health and crop productivity in China are discussed in the last part of the book.

Even though the task is daunting, the problem of air quality can be solved. Experience acquired in other urban areas such as London and Los Angeles (Parrish et al. 2016) shows that decisive action can be taken to reduce the emissions of primary air pollutants and of the precursors of secondary pollutants. China has already taken important steps toward an effective mitigation of air pollution. The objective of this volume is to provide fundamental elements that will help decision-makers design effective science-informed policies that will lead to long-term improvements of air quality and to successfully manage short-term air pollution

episodes that substantially affect the quality of life of the people and strongly impact the economy.

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